

MEASUREMENT TIPS

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A Low-Cost Solution to Measuring and Analyzing Jitter Using the Agilent 53230A Counter



Introduction

During data recovery, the relationship of the clock signal edge to the bits in the data stream is critical for error-free recovery. Ideally, the clock edge (rising or falling) on which recovery begins should occur at the center of the data bit. This relationship is shown in **Figure 1**. For the purposes of this paper, the clock edge of interest is the negative (falling) edge.

When jitter causes the clock edge to drift or shift from the intended center position, bit errors can occur.

In this measurement brief, we will explain how to use the Agilent 53230A counter to measure, calculate, and analyze jitter. Specifically, this includes:

1. Configuring the counter for time interval measurements.
2. Using the counter's statistics function to measure or calculate the jitter based on the time interval measurements.
3. Creating a histogram to show jitter type and distribution.

Snapshot

A small telecommunications start-up company has identified a niche market which larger telecomm companies, because of the expected return, have chosen not to pursue. To address the need within this market, the company is developing a receiver which requires a stable and clean clock signal for data recovery.

A key specification in the clock design is jitter tolerance—the drifting (shifting) of the clock's rising/falling edges. Company engineers noticed bit errors in the data recovery, which they traced to invalid edges caused by jitter within the clock signal. With its limited budget, the start-up needed an affordable way to measure and characterize the jitter. Using an Agilent 53230A universal counter, the engineers were able to identify the type of jitter present, establish magnitude benchmarks, and validate design changes to reduce jitter levels.

The math and graphics capabilities of the instrument provided the company with a one-box solution for statistical and graphical analysis.



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Configuring the counter for time interval

The start-up company's receiver design incorporates a 5 MHz clock (square wave). To begin the process of measuring jitter, the counter is configured for a single-channel time interval measurement between the rising and falling edges of a single clock pulse (1/2 clock cycle). **Figures 1 and 2** show the measurement parameters and configuration.

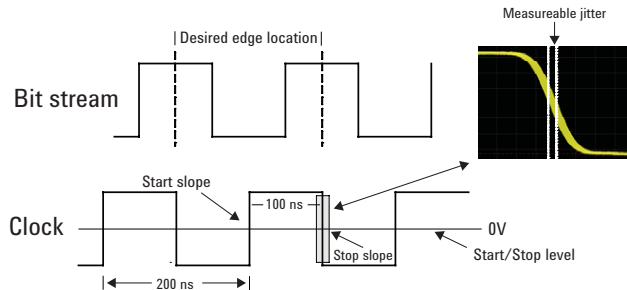


FIGURE 1: Time interval measurement of a 5 MHz signal

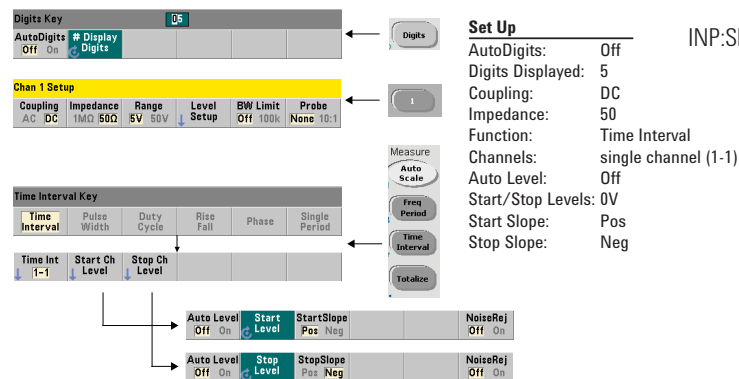


FIGURE 2: Front panel time interval measurement configuration

The equivalent SCPI commands for Figure 2 are:

```
*RST // start from a known instrument state
DISP:DIG:MASK 5 // disable auto-digit mode; set display to 5 digits
CONF:TINT (@1) // configure single-channel time interval measurements
SAMP:COUN 100E3 // arbitrarily set a sample (reading) count of 100k
INP:COUP DC // set DC coupling
INP:IMP 50 // set 50 ohms impedance
INP:LEV:AUTO OFF // disable auto level for start/stop thresholds
INP:LEV1 0 // start threshold at 0V
INP:LEV2 0 // stop threshold at 0V
INP:SLOP1 POS // start on positive (rising) edge
INP:SLOP2 NEG // stop on negative (falling) edge
```

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For faster measurement throughput, specify discreet parameter values rather than using automatic selection (i.e. auto-level, auto-range, auto-digit), as the parameter is evaluated prior to every measurement which can significantly affect throughput speed.

Enabling the counter statistics function

Once the time interval measurement is set up, the counter's statistics function can be enabled. Running statistics available for an increasing measurement count include mean value, maximum value, minimum value, standard deviation, and peak-to-peak value. Statistics are enabled from the front panel as shown in **Figure 3**.

FIGURE 3: Enabling statistics from the front panel



Programmatically, statistics are enabled by:

```
CALC:STAT ON // enable the math functions
```

```
CALC:AVR:STAT ON // enable statistics
```

After the measurement is configured and statistics are enabled, the measurements are started with the command:

```
INIT // start the measurements
```

Figure 4 is an example of the counter display showing the statistics of ~ 1,500 time interval measurements.

mean value of 1,526 time interval measurements

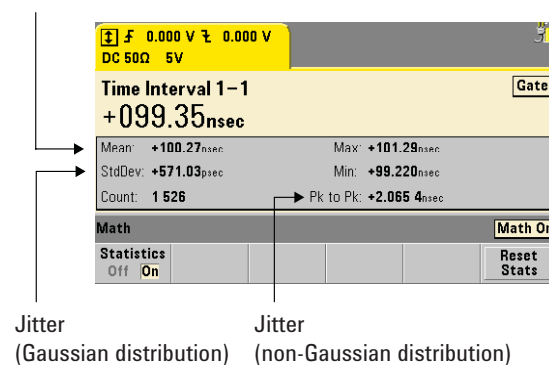


FIGURE 4: 5320A display with statistics enabled

Two elements of the statistics display represent jitter: standard deviation (StdDev) and peak-to-peak (Pk to Pk). Random jitter, which has a Gaussian distribution, is quantified by the standard deviation of the distribution. Deterministic (reproducible) jitter may have distributions that are non-Gaussian and, therefore, is represented by peak-to-peak measurements.

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The counter's default trigger source – internal, will cause the counter to immediately begin taking measurements or compute statistics as each function is enabled. Press **'Reset Stats'** on the front panel or send CALCulate:AVERage:CLear to reset the reading count and start a new set of measurements and statistics on the next internal trigger received. Note that changing any parameter in the counter configuration or enabling/disabling the statistics function also resets the reading count and starts a new set of measurements and statistics.

Using counter histograms to analyze jitter

A deciding factor in the start-up's decision to purchase the 53230A was the counter's trend chart and histogram features. Using histograms, the company can view the distribution shape and characterize the jitter as random (a Gaussian distribution) or as some other type. Knowing this can help pinpoint the source(s) causing the jitter.

The user has control over the number of bins, the lower and upper ranges of the histogram, and the representation of numeric data. Zoom, pan, and marker controls enable detailed analysis of an individual bin or a group of adjacent bins. Data from the histogram can be analyzed real time, or saved to internal memory or to an external USB memory device for analysis at a later date.

Setting up and enabling histograms

Histograms are based on counter measurement configurations that are generally set prior to enabling the histogram. The start-up company, using the same time interval measurement and throughput optimization, is interested in the distribution shape of the interference (signals) causing the jitter. Assuming the previous configuration, the histogram is set up from the front panel as shown in **Figure 5**.

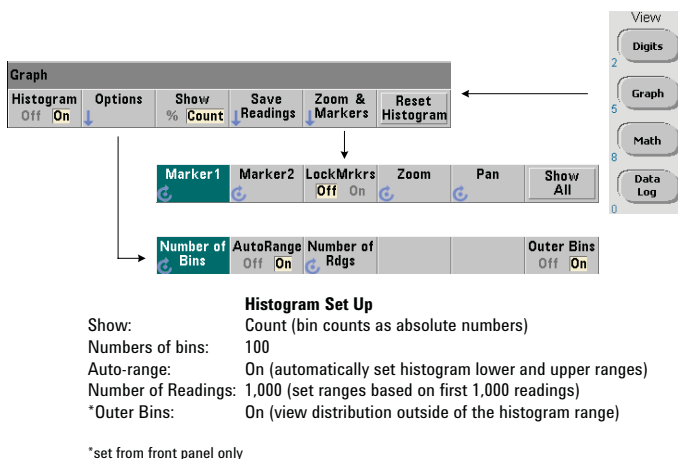
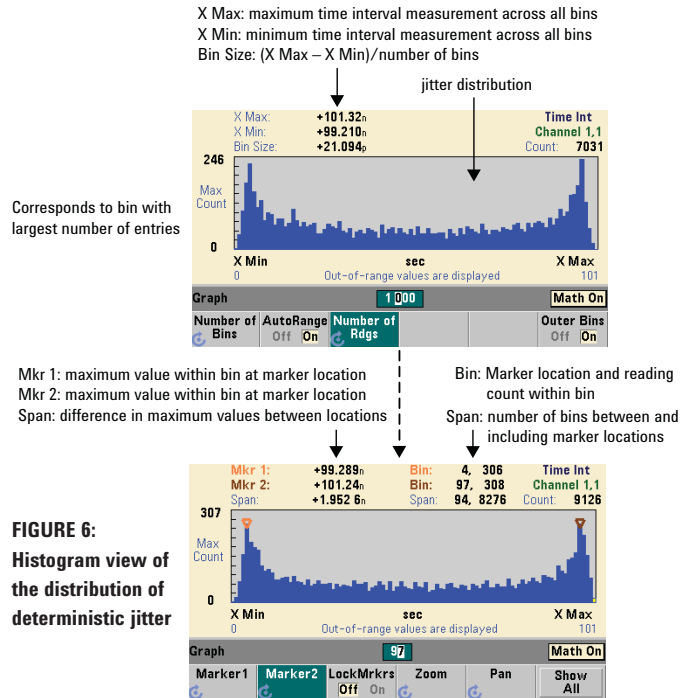


FIGURE 5: Enabling and configuring a histogram from the front panel

The equivalent SCPI commands for Figure 5 are:

```
CALC2:TRAN:HIST:POIN 100           // specify 100 bins
CALC2:TRAN:HIST:RANG:AUTO ON       // auto-select histogram ranges
CALC2:TRAN:HIST:RANG:AUTO:COUN 1000 // set ranges based on first 1,000 readings
CALC2:TRAN:HIST:STAT ON            // enable the histogram
```

Figure 6 is an example of a histogram display with the main histogram menu and the 'zoom & markers' menu selected.



The statistics and histogram functions can be enabled at the same time; however, they are not synchronized. Each function corresponds to a different reading count based on when the function was enabled and whether or not the function was reset and restarted. Pressing the **'Digits'** and **'Graph'** keys switch the display between a numeric representation (statistics) and a graphical representation. Neither function is reset when this occurs.

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Although automatic parameter selection (i.e. auto-level, auto-range, auto-digit) is not recommended when considering measurement throughput, automatic selection of the histogram range can save time. Automatic range setting is a one-time set up for each histogram which occurs after an initial set of readings have been obtained. (The initial set of readings is included in the distribution.)

If an unexpected number of readings are present in the outer bins (out of range), consider increasing the reading count specified for automatic histogram range selection. By sampling a larger number of readings, a more accurate distribution can be recorded. Up to 1,000 readings can be specified.

Conclusion

The math and graphics functions of the 53230A extend the counter's ability to measure and analyze signal components such as random and deterministic jitter. The ability of the counter to analyze data real time or post-process, combined with a wide variety of measurement functions, make the counter an obvious choice for companies of any size sensitive to price and performance. A full-feature front panel and complimentary SCPI command set make the counter ideally suited for bench top use or for integration within a system via its LAN, USB, or optional GPIB interface.

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**Learn more about
Agilent 53200 Series
frequency counters**

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The image shows three Agilent 53200 Series frequency counters. The background features various signal waveforms and graphs, including a histogram labeled 'Count', a waveform labeled 'X Min', and a graph labeled 'Y Min'. A large digital display shows the value '10.099 969 829'. Other text on the background includes 'Out-of-range', 'Vmin: -1.01 V', '10.181 969 382MHz', 'Reading', and 'Math On'.

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